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Short Communication

Rainfall trend, distribution and its role on crop yields in rainfed areas of Prakasam district of Andhra Pradesh - A Case study

L.K. PRASAD*, R. SRINIVASULU, A.R. PANDA, K.C. CHENCHAIAH and M. PRABHAKAR[1]

CTRI Research Station, O.V. Road, Kandukur-523 105, Andhra Pradesh

[1] Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad-500 059, Andhra Pradesh

**E-mail: lkprasad123@gmail.com*

Rainfall is the only source of water /soil moisture for most of the crops in the rain fed areas and is the most important climatic factor for crop production in Prakasam district of Andhra Pradesh. Rain is meager in *Kharif* season and very unevenly distributed. As a result, there is no assured *Kharif* crop in this area. However, due to good rain, *Rabi* crop season (September to February) only promises an assured crop. It is essential to plan agriculture on a scientific basis for making best use of rainfall pattern of this area. Chickpea and tobacco are important *rabi* crops in the rainfed area grown from October to February (N.E monsoon). The yield and quality of these crops is dependent on the quantity and distribution of rainfall during the cropping period. In recent years, the quality of produce of *rabi* crops is not maintained leading to large scale economic loss to the farmers in this area.

Prakasam district is located between 14°57' to 16°17' N Latitudes and 78°43' to 80°25' E Longitudes. It is flanked by Bay of Bengal on the eastern side. In order to represent the rain fed area in the district for a case study, one mandal *i.e.,* an administrative unit (Kandukur) was selected, which is totally dependent on rainfall mainly from North-East monsoon.

The average annual rainfall received in the district is 757 mm. South-West and North-East monsoons contributes 44.2 and 50.5 per cent rainfall, respectively. In recent years, the rainfall distribution is becoming erratic resulting in frequent crop failure by way of submergence or prolonged drought. The frequent aberrations necessitate studying the rainfall trend during crop growth period and its distribution for meaningful crop planning. Sinha Ray and Srivastava (2000), Sadhukhan *et al*., (2000), Kothawale *et al.,* (2010) studied trends of annual and seasonal rainfall at many locations and at different scales over India. Sequences of dry and wet spells are important factors for rain fed crops.

Rainfall analysis and trend detection

Weekly rainfall data from 1920 to 2009 of Kandukur mandal of Prakasam district of Andhra Pradesh was used as a representative case for trend detection analyses. Mann–Kendall nonparametric test, as described by Sneyers (1990), was applied in order to detect the presence of any trend. This test was used by several researchers to detect trends in hydrological time series data, especially groundwater level, stream flow pattern, rainfall, etc. (Serrano *et al*., 1999; Brunetti *et al*., 2000 a; Subash and Ram Mohan, 2010).

$$S = \sum_{i=1}^{n-1} \left[\sum_{j=i+1}^{n} \mathrm{sgn}\,(Rj - Ri) \right] \qquad \text{..... (Eq 1)}$$

Where sgn(x) = 1 for x > 0; sgn(x) = 0 for x = 0; sgn(x) = -1 for x < 0 and R=rainfall.

A positive value of S indicates an increasing trend and vice versa. The test of significance (z) was compared with table value at 99% (2.576), at 95% (1.960) and at 90% (1.645) confidence level, respectively. Trend in annual, seasonal and monthly rainfall was also studied using above procedure. To estimate the true slope of an existing trend the Sen's nonparametric method was used (Shamshuddin Shahid, 2010). The district level cured leaf yield data of FCV tobacco for the years 2004 to 2009 was averaged from the data different auction platforms in Prakasam district of tobacco board and CTRI research station at Kandukur while Chickpea grain yield data was obtained from district level statistics of agriculture department, A.P.

General rainfall feature

Rainfall data at Kandukur, a representative of rain fed area under Prakasam district, was studied on weekly basis. Long term (1920-2009) average annual rainfall at Kandukur is 925 ± 234 mm. Mann-Kendall test statistic (S= 833.0) showed a significantly positive trend ($\alpha = 0.05$). Long term mean weekly rainfall (1920-2009) at Kandukur indicates higher rainfall during 43rd (22-28th October) to 45th (5th - 11th November) weeks. Amount of rainfall gradually increases from 17th week (23-29th May) to 44th week (29th October to 4th November) and then decreases from 45th week onwards.

Weekly rainfall trend

The results of the analysis indicated that the trend(*S* values) is either positive (increasing) or negative (decreasing) in weekly rainfall over 90 years. Overall rainfall distribution and its trend showed that out of 52 standard meteorological weeks, 25 weeks showed decreasing trend while remaining 27 weeks showed increasing trend. The 23rd Standard Meteorological Week (4th to 10th June) showed significant increasing trend of rainfall (at 90% confidence level). Mann-Kendall test statistic (z) and trend(s) values are S= 477.0 and z = 1.662.

During *Kharif*, rainfall of 24th to 28th weeks (11th -17th June to 9th -15th July) showed decreasing trend. As a result sowing, germination and establishment of *Kharif* crop is uncertain. There is an increasing trend during 30th to 34th (23-29th August to 20-26th September) weeks indicating a shift. Rain during this period after prolonged drought helps in field preparation for the *rabi* crop during subsequent weeks. Therefore, crop calendar needs a shift with respect to land preparation and sowing. In *rabi* season, 9 weeks showed increasing trend and 12 weeks showed decreasing trend while in summer 5 weeks showed decreasing trend only. Mean weekly rainfall of 90 years varied from 0.36 mm (14th week i.e. 2nd to 8th April) to 80.45 mm (44th week i.e. 29th October to 4th November). The coefficient of variation is between 1.11 and 7.95.

Monthly rainfall trend

Monthly rainfall data (1979-2008) of *Prakasam* district showed that highest mean rainfall (191.6 mm) was recorded in the month of October while lowest rainfall (10.2 mm) was in January. Mann-Kendall trend was positive (z-value: 1.36) and Sen's estimator (Q) i.e. magnitude of change (2.50 mm year^{-1}) was highest in October (Tab.1). The rainfall during *June, July, September, November and December* months, even though non-significant, showed a decreasing trend over 30 years, The trend indicated a gradual decrease in rainfall during N-E monsoon months, adversely affecting the crop growth especially in rain fed light soil area.

Seasonal rainfall trend

Long term average rainfall for *Kharif* and *Rabi* were 389.5 ± 125.7 mm and 362.5 ± 139.1 mm with Q value -0.396 and -0.125, respectively (Table2). Seasonal trend analysis showed that both the crop seasons were following a negative trend in rainfall except in summer.

Table 1 : Descriptive and trend statistics of 30 years (1979-2008) monthly rainfall of Prakasam district of Andhra Pradesh

Month	Mean (mm)	Standard deviation	Variation coefficient	S.Em	Mann-Kendall test (z-test value)	Sen's estimator (Q) (mm year^{-1})
January	10.2	15.4	1.49	2.81	-0.90	-0.031
February	10.8	26.6	2.42	4.85	0.37	0.000
March	13.4	23.2	1.70	4.23	0.22	0.000
April	13.0	17.1	1.30	3.13	0.59	0.083
May	43.4	57.6	1.30	10.51	0.39	0.200
June	62.1	55.5	0.88	10.13	-0.21	-0.079
July	93.1	48.4	0.51	8.84	-1.09	-0.800
August	102.4	67.8	0.65	12.38	0.11	0.120
September	131.8	68.9	0.51	12.58	-0.50	-0.715
October	191.6	101.7	0.52	18.57	1.36	2.500
November	123.9	97.6	0.77	17.82	-0.93	-1.744
December	26.1	46.3	1.75	8.46	-0.86	-0.177

Table 2 : Descriptive and trend statistics of 30 years (1979-2008) seasonal rainfall of Prakasam district of Andhra Pradesh

Month	Mean (mm)	Standard deviation	Variation coefficient	S.Em	Mann-Kendall test (z-test value)	Sen's estimator (Q) (mm year^{-1})
Kharif (June-Sep)	389.5	125.7	0.32	22.94	-0.02	-0.396
Rabi(Oct-Feb)	362.5	139.1	0.38	25.39	-0.04	-0.125
Summer(Mar-May)	69.9	65.3	0.92	11.91	0.93	0.643

Even though the seasonal coefficient of variation of rainfall in *kharif and rabi* seasons (0.32 and 0.38) is less, the monthly coefficients of variation within monsoon season is higher (0.51-2.42) indicating an erratic and larger intra month variation i.e rainfall variation of a month over years during South-West as well as North-East monsoons (Tables 1 and 2). This indicates that development of supplementary irrigation facility is essential to sustain productivity. Studies on the trends in seasonal rainfall in the *Shivalik* foothill region as part of crop planning efforts showed high variability in *rabi* seasonal rainfall and indicate the need of supplemental irrigation for successful *rabi* crops (Agnihotri, 1999).

Trends during rabi crop season

During the *rabi* crop season i.e. the North-East monsoon period, the changes in actual weekly rainfall was observed during critical growth periods of *rabi* crop. During the period of field preparation a negative trend and low rainfall (11^{th} - 17^{th} June to 9^{th} -15^{th} July) make field preparation difficult. A positive trend during initial crop establishment stage was observed. Increased rainfall during this period makes the just sown seed to rot and just planted crop to weather out due to root decay and other stresses. A decreasing or negative trend was observed in weekly rainfall during the initial period of active growth. Similarly, the trend was negative in almost all the weeks during maturity and harvesting stages of the crop. The negative rainfall trend during critical crop growth period of *rabi* crops adversely affects the quantity and quality of produce. In order to overcome this difficulty one-two week shift from recommended date of sowing would be beneficial since the trend is increasing during 49^{th} to 51^{st} weeks in December and 3^{rd} week of January as it helps in better crop growth and yield. Similar studies of rainfall pattern during crop seasons in relation to yield were done in rice and wheat crops by Subash and Ram Mohan, (2010).

Spatial mapping and seasonal rainfall analysis of Oct-Feb, 2009 showed an overall decline of 32 % in rainfall from normal rainfall during *rabi* crop season in entire Prakasam district. Area having a normal rainfall of 400-500 mm and >500 mm have received 100-300 mm rain only. Reduction in quantity of rainfall and its distribution has adversely affected *rabi* crop growth and also the quality of produce (Table3). In the deficit rainfall years, yields were reduced and because of the low quality of the produce, the price earned was low, which adversely affected livelihoods.

The loss in yield in *rabi* crops was studied in relation to *rabi s*eason rainfall (October to February) during 2004-2009. It was observed that October month received excess rainfall coincided with the sowing /plant or crop establishment stage affecting chickpea and tobacco crop. However, little deficit or excess amount in rainfall with equally distributed rainy days in October and November (55-70% of rainfall) improved the productivity in tobacco up to 200 kg ha^{-1} of leaf yield and in chickpea up to 400-600 kg ha^{-1} of grain yield. Excess rainfall due to cyclone (88 mm) during February, 2008 before harvesting of chickpea and a deficit of 100 mm actual rainfall from normal during *rabi* affected yield up to 30%.

It was observed that the grain quality and 100 grain weight of chickpea was adversely affected due to drought periods. While cyclonic rains leading to submergence and water logging, the seed germinated in the field and also developed black spot. The 100 grain weight reduced by 17-20 percent in both *desi var.Annegiri* as well as *Kabuli*

Table 3 : Change in seasonal rainfall (October-February) and productivity of *rabi* crops in *Prakasam* district, A.P.

	Rainfall(mm)						Δ + / - (mm)	Yield Kg ha^{-1}	
Year	Oct	Nov	Dec	Jan	Feb	Total	from normal*	Tobacco (cured leaf)	Chickpea (grain)
2004-05	136.1 (8.0)	47.6 (3.0)	0.0	0.2	4.4	188	-222	1181	1288
2005-06	431.6 (13)	47.8 (3.0)	6.1	0.0	0.0	486	76	1393	1943
2006-07	201.3 (6)	154.2 (7)	9.7	0.0	7.0	372	-38	1232	1648
2007-08	167.6 (8)	43.7 (3)	0.4	0.0	87.7	300	-110	1205	1527
2008-09	120.0 (6)	293.0 (7)	5.5	1.0	0.0	420	10	1332	1761

* Normal rainfall during rabi : 410 mm; Figures in parenthesis represent number of rainy days.

*var.,*KaK-2 varieties. It implied that not only decrease in rainfall but also abnormal, irregular or excessive amounts of rainfall seriously reduce the quality and quantity of the yield in rain fed *rabi* crops.

Usually, chickpea is recommended to sow during 2nd to 3rd week of October. However, in the present study it is evident that, sowing of chickpea will be beneficial during 1st week of November in red soils and 2nd week of November for black soils. It is because of increasing trend in rainfall in 3rd and 4th weeks of October leading to continuous saturated condition of the soil and seed rotting in the field.

Third week of September is recommended as optimum period for tobacco transplanting. But because of decreasing trend of rainfall in second week of September (20-30 mm), land preparation is increasingly becoming difficult. Therefore, practically it is becoming difficult to transplant tobacco in 3rd week of September. One to two week shift to delay transplanting can be recommended in order to achieve better land preparation and high percentage of crop establishment, especially for the light soil area.

The shift in rainfall trend observed in the rain fed area of Prakasam district is significant in the context of future planning of commercial and other crops. Shift in weekly as well as monthly trends even though statistically non-significant, indicated that rainfall trend was irregular and declining during important crop growth periods. Contrastingly, average annual trend of rainfall was increasing but distribution and pattern was erratic.

Thus, the change in climate at local levels necessitate to undergo advance planning and local level mitigating strategies help in improving productivity and sustain traditional livelihoods in rain fed areas. Monthly rainfall analysis indicated a decreasing trend during September-November-December months and an increasing trend in the month of October. Sowing of chickpea during 1st week of November in red soils and 2nd week of November for black soils of Prakasam district will be helpful in avoiding continuous saturated conditions due to excess rainfall in 3rd and 4th weeks of October in chickpea crop. Tobacco transplanting during third week of September is recommended as optimum period because of decreasing trend in rainfall during 2nd week of September. One to two week shift to delay in transplanting of tobacco seedlings to achieve better land preparation and high percentage of crop establishment, especially for the light soil areas of Prakasam district.

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